**Mr. Alpert’s Advanced Physics**

**Measuring the Index of Refraction of Jello**

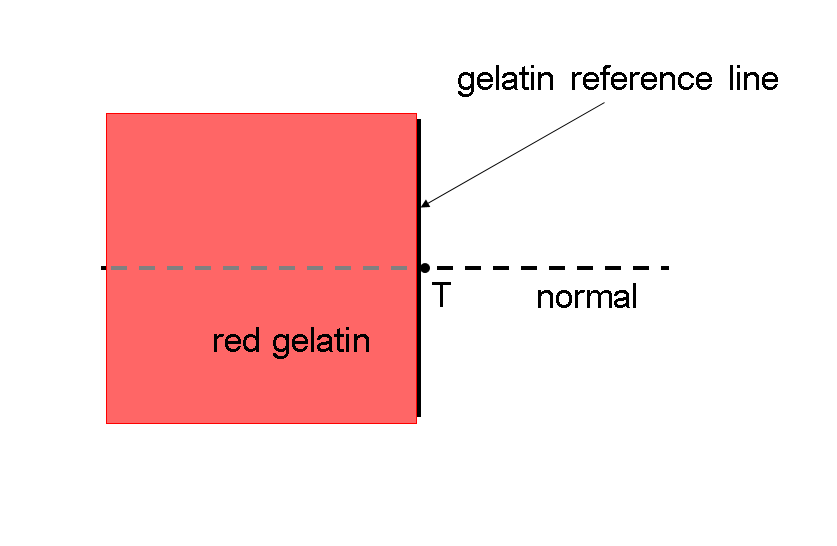
**Background:**

A Laser, or Light Amplification by Stimulated Emission of Radiation, has a high degree of spatial coherence. A high degree of spatial coherence means that the light that is being emitted from the laser is very concentrated making the visible distance that light is traveling much further than that of a standard light source. Another important property of lasers is that they only produce light from a single wavelength. The different wavelengths of light produced from the laser travel at different speeds making some colored lasers have a greater visible distance which they travel. Due to the laser's unique properties, it has gained significant popularity in various fields of science and the military. In the scientific applications, such as lunar laser ranging, the laser is required to travel from one medium to another, thus causing light refraction  This light refraction can be accounted for if the index of refraction is known for both mediums and the incident angle. If a scientific experiment that used a laser, whose light was traveling through different mediums, was to switch their color of laser then their measurements would be different. This would happen because the different frequencies of the lasers which were used.

**Once again, you will be using lasers in this experiment. NOTE: The laser can cause permanent eye retina damage.   
Students should always be aware exactly where the laser is pointed. Students should point the laser in a safe direction as they set it up.**

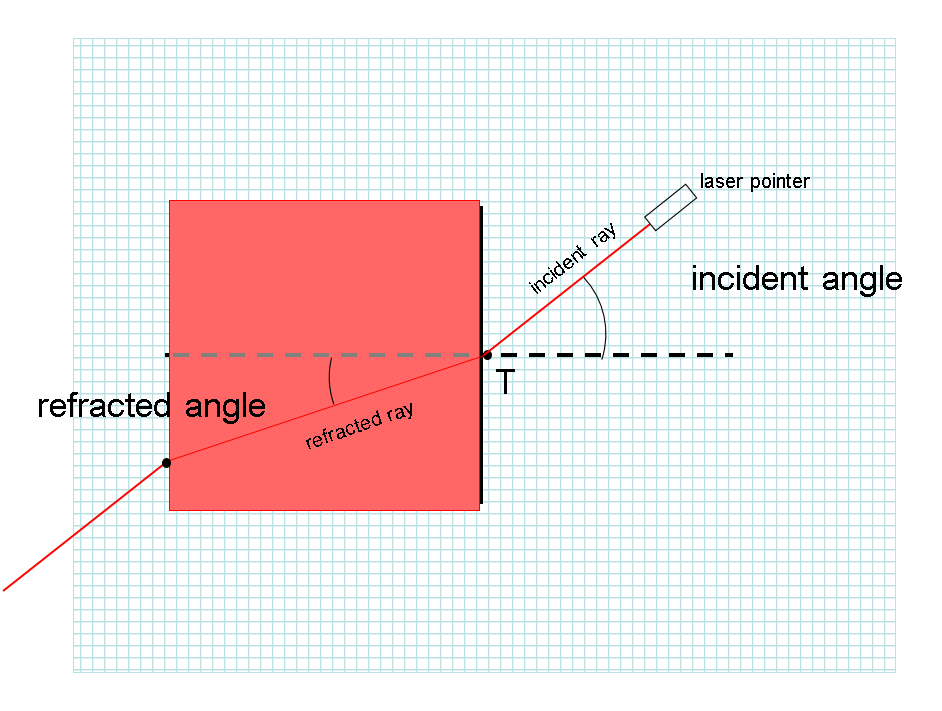
**Prepare the gelatin samples for testing**

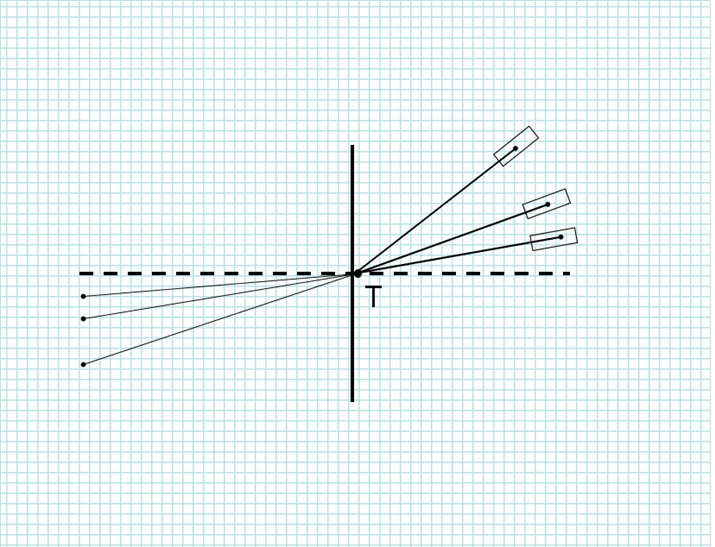
1. Cut a 5 cm by 5 cm square (two inches by two inches) of Jell-O from each pan, i.e. red Jell-O, yellow Jell-O and plain gelatin (if available).

1. Place the sample on a piece of waxed paper.
2. Trim the wax paper around the edges of the gelatin.
3. Place the waxed paper and sample on the overhead graph plastic sheet that Mr. Alpert will give you. This plastic sheet will have a reference line and a shadow of Jell-O on it as shown below.  
   5. Align one side on the vertical line.   
     
   6. Draw a vertical line to represent the surface of the gelatin sample. Mark the midpoint.   
     
   7. Draw a long horizontal normal dashed line through the midpoint.   
     
   8. Mark the point where the normal meets the surface of the gelatin. Label it “T” for target.

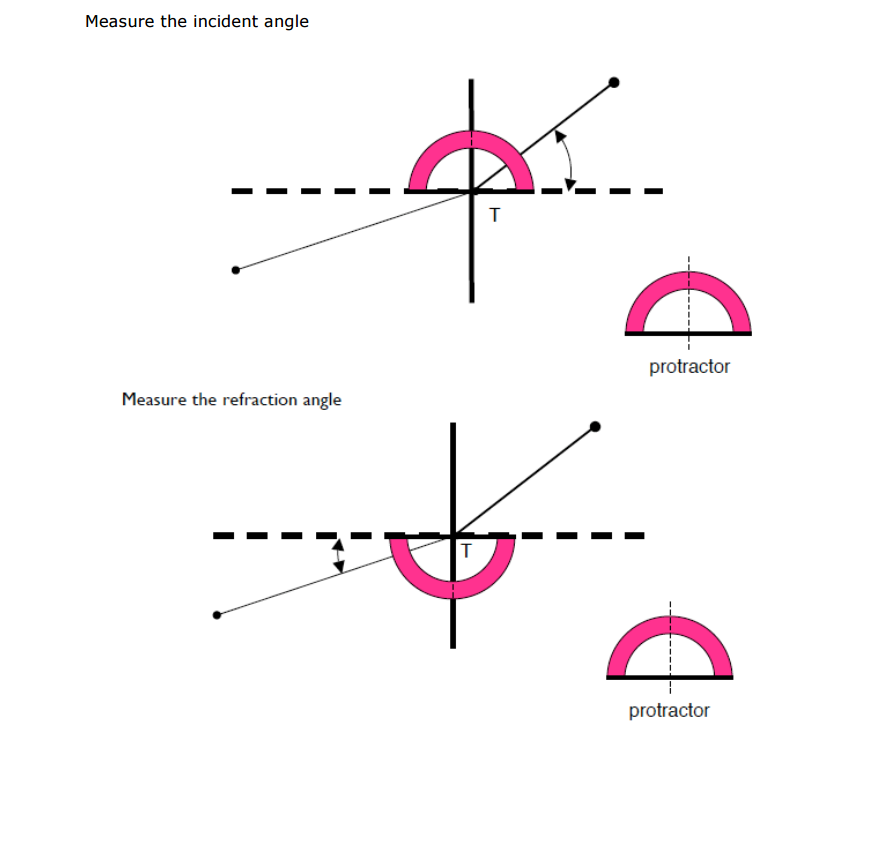
***Note: You may measure incident and refraction ray angles using a protractor or measure the x,y coordinates of each reference point (see step 11 and 13). The x,y coordinate method allows you another method to find the sine of the angle.***

**Measure incident and refractive rays at least three times**

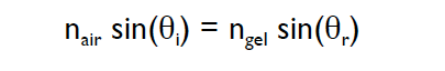
1. Pick three positions to fire the beam into the gelatin above the normal and below the normal, for a total of six positions.
2. Stand the laser and point it at the gelatin.
3. Clamp the laser “on” then align the beam so that it enters the gelatin directly over point “T.”
4. Carefully hold down the laser pointer with one finger, and trace the sides of the binder clip on the graph paper. Label it “i-1.” Later, you will use these reference lines to mark the position of the laser beam.
5. Mark the location where the refracted beam exits the gelatin. Label it “r-1.” \*Be careful not to nudge the gelatin. If you accidentally move the gelatin a bit, just realign it with the vertical line. Or, you may decide to redo your measurements.
6. Move the laser to a new incident beam position.
7. Repeat the above steps (2 – 6) for the remaining positions.
8. Remove the gelatin from the graph paper.
9. At each of the incident beam positions, mark a midpoint between the reference lines.
10. Lightly draw a line segment between each incident beam point (i-1, i-2, i-3) and the point “T.”
11. Measure the angle between each incident line and the normal. Write down your data in your data table. \*Alternative: measure the x and y coordinates for the point, with “T” as the origin.
12. Lightly draw a line segment between each refracted beam point (r-1, r-2, r-3 …) and “T.”



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| --- | --- | --- | --- | --- | --- |
| Trial # | Color of Jell-O | Incident angle  i | sin (i) | Refraction angle  r | sin (r) |
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1. Measure the angle between the refracted line and the normal. Write down your data in your data table. \* Alternative: measure the x and y coordinates for the point, with “T” as the origin by counting boxes on the graph paper. You may use the Pythagorean Theorem to determine the sides of the triangle and then use inverse sin to determine the angle in each case.

You are trying to find **n**gel.  
You know through Snell’s Law the relationship between the variables:



index of refraction of air (1.000) times the sin of the angle of incidence equals the index of refraction of the Jell-O times the sin of the angle of refraction.

**Calculations**

Use your data table to calculate the index of refraction of clear gelatin and red Jell-O

Show your calculations

**Wrap up questions: Note: repeat the question in your answer**

1. Name the independent, dependent and controlled variables.
2. What happens to the speed of the laser as it passes through the Jell-O?
3. Knowing that velocity equals frequency times wavelength what happens to the wavelength of the light as it passes through the medium (assume that the frequency does not change) ?
4. Does the shape of the Jell-O affect the angles? How?
5. Does the color of the Jell-O affect the index of refraction? Why or why not?
6. Does the color of the laser affect your outcome? Why or why not?
7. As the angle of incidence changes, what happens to the refraction angle?
8. List at least three errors that might contribute to inaccurate results.
   1. Here are some hints: was the Jell-O perfectly translucent? Were there any imperfections in the Jell-O which might have caused the light ray to be disturbed? How accurate were you in measuring/ marking your incident and refracted rays? What is the degree of accuracy of your instruments? Were the sides of the Jell-O parallel? *You must not copy these hints but must explain why they affected your result.*
9. What value did you find for the gelatin index of refraction?
10. The following values have been obtained by others: 1.36 for the yellow gelatin, 1.33 for the red gelatin, and 1.19 for the clear gelatin.  
    *NOTE: your value may not agree with the published one since you do not know the ratio of water to Jell-O used by others. In this case, one packet of Jell-O was mixed with two cups of water.*
11. Calculate your percent differences.
12. Use your value for the index of refraction to calculate the speed of light in Jell-O and in the clear gelatin.

